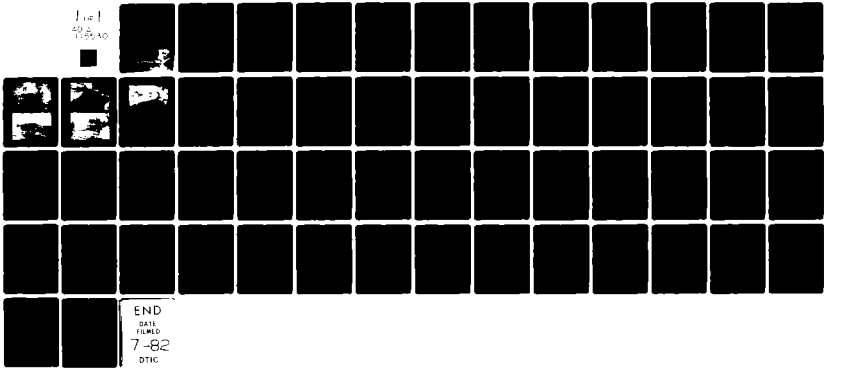
AD-A115 530 AIR FORCE ARMAMENT LAB EGLIN AFB FL F/G 8/1
BENTHIC MACRO-INVERTEBRATES OF ROCKY CREEK, EGLIN AIR FORCE BAS--ETC(U)
OCT 81 J F SCHEIRING, R C CREWS, S M LEFSTAD
UNCLASSIFIED AFATL-TR-81-95 SBI-AD-E800 496 NL



END
DATE FILMED
7-82
DTIC

12

AFATL-TR-81-95

Benthic Macro-Invertebrates of Rocky Creek, Eglin Air Force Base, Florida

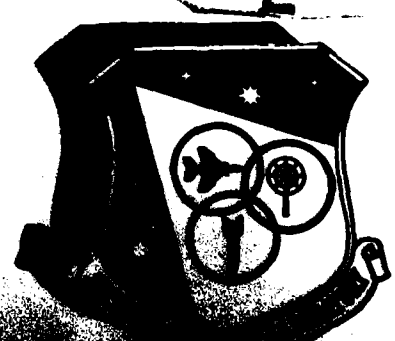
Joseph F Scheiring
Richard C Crews
Sandra M Lefstad

ENVIRONICS OFFICE

OCTOBER 1981

FINAL REPORT FOR PERIOD JULY 1978-JUNE 1979

Approved for public release; distribution unlimited



Air Force Armament Labo
AIR FORCE SYSTEMS COMMAND ★ UNITED STATES AIR FORCE ★ EGLIN AIR F

NOTICE

Please do not request copies of this report from the Air Force Armament Laboratory. Additional copies may be purchased from:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Federal Government agencies and their contractors registered with Defense Technical Information Center should direct requests for copies of this report to:

Defense Technical Information Center
Cameron Station
Alexandria, Virginia 22314

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFATL-TR-81-95	2. GOVT ACCESSION NO. AD-A115530	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) BENTHIC MACRO-INVERTEBRATES OF ROCKY CREEK, EGLIN AIR FORCE BASE, FLORIDA		5. TYPE OF REPORT & PERIOD COVERED Final Report July 1978 - June 1979 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Joseph F. Scheiring Richard C. Crews Sandra M. Lefstad		8. CONTRACT OR GRANT NUMBER(s) In-House
9. PERFORMING ORGANIZATION NAME AND ADDRESS Environics Office Air Force Armament Laboratory Eglin Air Force Base, Florida 32542		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PE: 62602F JON: 06AL-01-10
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Armament Laboratory Armament Division Eglin Air Force Base, Florida 32542		12. REPORT DATE October 1981 13. NUMBER OF PAGES 54
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Availability of this report is specified on verso of front cover

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aquatic Baseline Data	Diversity Indices
Aquatic Community Trophic Structure	Eglin AFB Test Area Streams
Aquatic Insects	Rocky Creek, Eglin AFB
Benthic Macro-Invertebrates	Similarity Indices

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A baseline study of benthic macro-invertebrates was conducted in Rocky Creek, a stream draining several test ranges used for the testing and evaluation of conventional munitions. The purpose of this study was to determine the numbers and kinds of benthic macro-invertebrates inhabiting the stream. This included an analysis of community composition, trophic structure, and seasonal and annual diversity patterns. A total of 85 taxa (mostly genera) was collected from July 1978 to June 1979. Sixty-five taxa were collected by quantitative

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Item 20 (Concluded). methods (ponar grab) and 20 additional taxa were collected by qualitative methods (light trap and/or kick sample).

Aquatic insects made up 89% of the total macro-invertebrates collected. The Diptera were the most abundant group accounting for 65% of the total with the Chironomidae comprising from 45 to 75% of the total invertebrate fauna of each site. Other important groups included: Oligochaeta, Coleoptera, Trichoptera, Plecoptera, Odonata, and Ephemeroptera. The fauna at the sites were similar with sites sharing from 71 to 86% of their taxa. The differences in the fauna among stations are probably due to site differences.

The annual diversity values ranged from 3.063 to 1.836 while the evenness ranged from 0.597 to 0.382. The annual richness ranged from 35 to 27. The mean monthly diversity varied between 2.283 and 1.444 while the mean monthly evenness varied from 0.741 to 0.510. The mean monthly richness ranged from 12.1 to 8.8. The seasonal and annual patterns of diversity and evenness were most affected by the larval density of chironomids. The seasonal changes in community composition and richness were due primarily to drift and life histories of the taxa.

The community trophic analysis showed that collectors and predators were the dominant groups and had fairly constant abundances at all sites. The number of shredders decreased with increasing stream order while filterers and scrapers increased. Functional group abundance and composition changed seasonally at each site due to the life histories of the individual insects and to stream conditions. The results of this study conform, very generally, to the River Continuum model.

PREFACE

This technical report discusses a portion of the work performed at the Air Force Armament Laboratory, Armament Division, Eglin Air Force Base, Florida, under Exploratory Development Project 06AL0110 during the period July 1978 to June 1979.

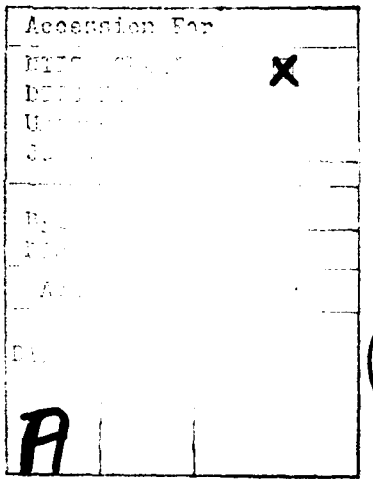
The sources and manufacturers of materials and equipment used in this study are identified for reference only and do not constitute endorsement of the companies or products by the United States Air Force.

This report has been reviewed by the Information Officer (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER:

Joe A. Farmer
Chief, Environics Office



(The reverse of this page is blank)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (continued)

SECTION I

INTRODUCTION

Since November 1974, Air Force Armament Laboratory (AFATL) personnel have been engaged in an effort to establish the existing site characteristics for several Eglin AFB test areas. These test areas are utilized for the testing of conventional munitions. This effort was initiated to meet the Council of Environmental Quality (CEQ) guidelines and Air Force regulation requirements to establish the existing site characteristics of these test areas for environmental documentation.

Many streams originate on, flow through, or otherwise drain these test areas; therefore, an essential component of any site description is aquatic baseline data. For this reason, the study reported here was conducted. While this study was concerned with only one area of Eglin AFB, the Rocky Creek drainage area, it does give an indication of the invertebrate fauna of the entire reservation. The only other studies of the invertebrates of Eglin AFB have been on the terrestrial fauna (Reference 1). Studies of the ichthyofauna of the area have also been previously published (References 2 and 3).

The purpose of this study was to determine the numbers and kinds of macro-invertebrates found in Rocky Creek. This included an analysis of community composition, trophic structure, and seasonal and annual trends in diversity. The present study allows us to make some general statements about water quality in Rocky Creek and will be useful for comparison with future studies on the same area. All specimens were preserved and catalogued and a permanent reference collection is stored at the Environmental Research Facility, Building 574. The remaining specimens are stored in the Aquatic Insect Collection of The University of Alabama.

SECTION II

DESCRIPTION OF THE STUDY AREA

Eglin AFB Reservation is located in northwest Florida and extends into Walton, Okaloosa, and Santa Rosa Counties. Most of the watersheds are sand hills with a pine-oak association. The soils are primarily acid sands of the Lakeland series. The streams in the area, including Rocky Creek, are generally clear with moderate to fast flowing water. The bottom substrate is generally sand with detritus and leaf litter collecting along the channel edges and around patches of vegetation.

The three factors most significantly affecting water quality on Eglin AFB are climate, geomorphology and soil conditions, and land use patterns. The effects of these factors have been discussed by Crews, et al. (Reference 4).

Rocky Creek, located in the eastern portion of the reservation, was sampled at 5 sites representing three stream orders (Figure 1). Sites 1 and 2 (Figures 2 and 3) were first-order headwater streams. Site 3 (Figure 4) was a second-order stream that had a small impoundment caused by a raised road culvert just above the collection area. The substrate at site 3 consisted of sand and some gravel. Sites 4 and 5 (Figures 5 and 6) were third-order streams. Site 4 was at the junction of an unnamed tributary and Rocky Creek. All of the sites, except site 3, had fairly heavy canopy cover. Site 3 was very open with few trees on or even near the floodplain. As a result of this, the detritus per unit area was much lower at site 3 than at the other sites.

Table 1 gives a summary of the physical and chemical conditions at each of the collection sites. In an earlier publication, Crews, et al. (Reference 4) studied the physical and chemical conditions of selected streams and ponds on Eglin AFB, including some of the sites on Rocky Creek used in the present study. They found few significant seasonal changes in conditions at any one site. The results of a comparison of sites (Table 1) indicate that all sites are significantly different with respect to at least some physico-chemical parameters. This implies that the habitats and micro-habitats available for macro-invertebrates differ somewhat among the sites.

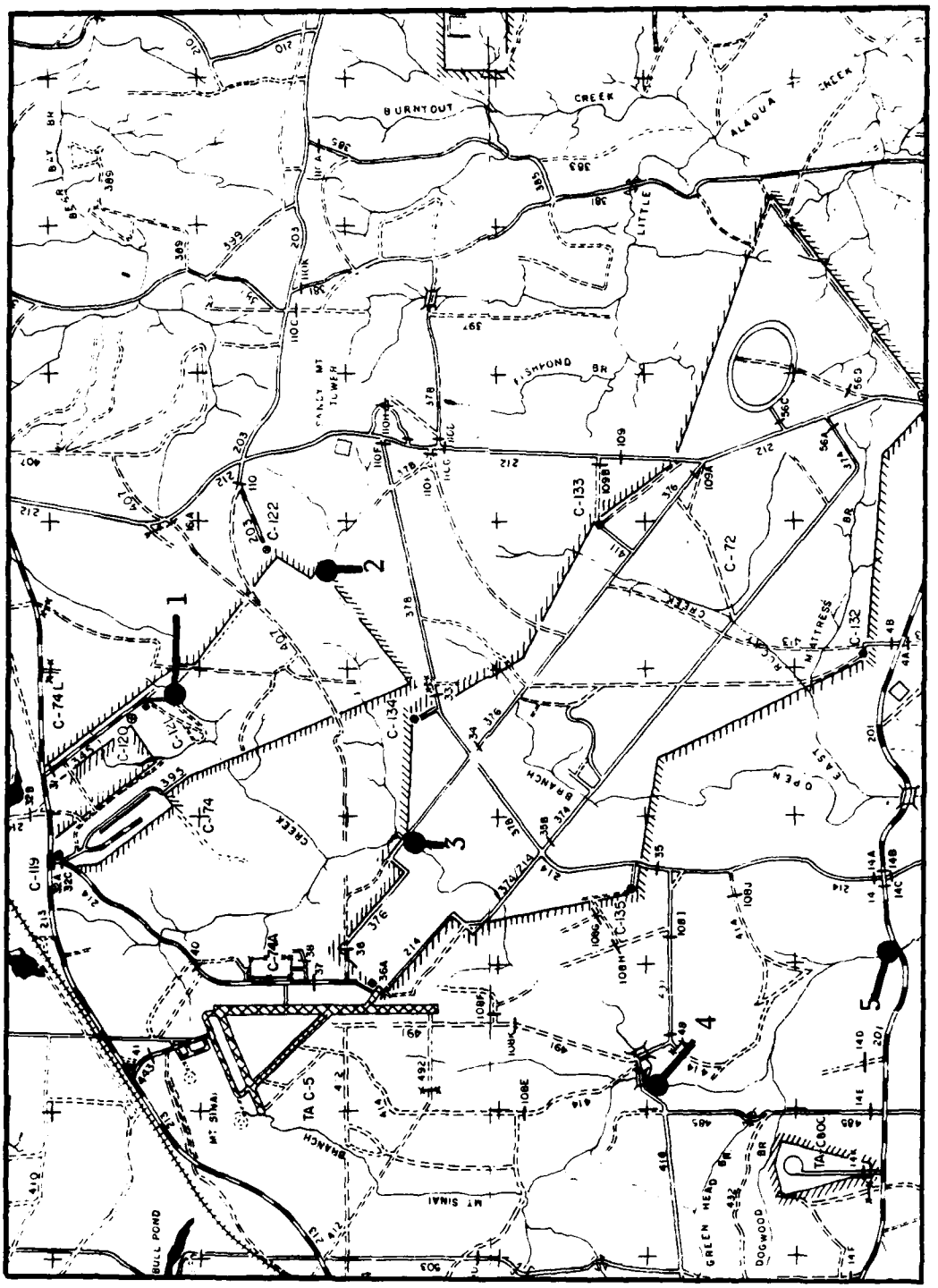


Figure 1. Five Collection Sites on Rocky Creek, Eglin AFB, Florida

Figure 2. Collection Site 1 on Rocky Creek

Figure 3. Collection Site 2 on Rocky Creek

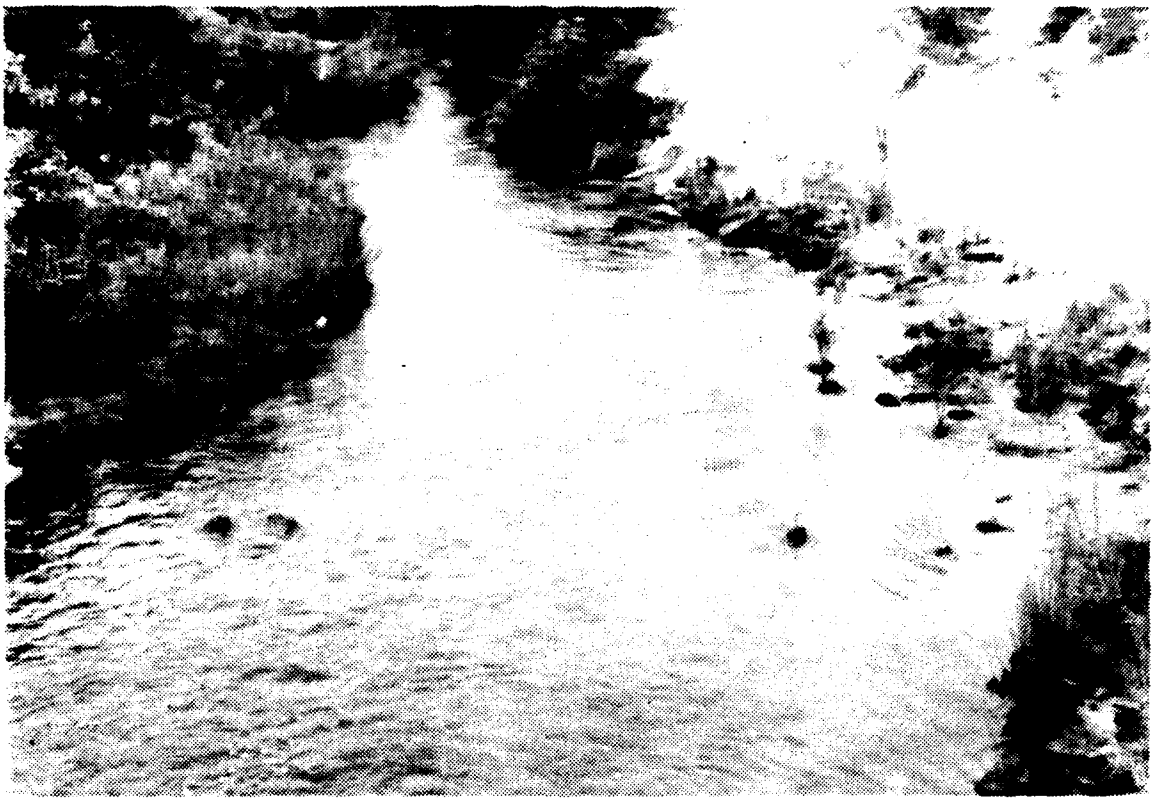


Figure 4. Collection Site 3 on Rocky Creek

Figure 5. Collection Site 4 on Rocky Creek

Figure 6. Collection Site 5 on Rocky Creek

TABLE 1. MEAN (± S.D.) VALUES FOR MEASURED PHYSICO-CHEMICAL PARAMETERS OF THE ROCKY CREEK COLLECTION SITES (pH VALUES ARE MEANS FROM NOVEMBER 1978 TO JUNE 1979 ONLY). MEANS IN THE SAME COLUMN FOLLOWED BY THE SAME LETTER EXPONENT ARE NOT SIGNIFICANTLY DIFFERENT ($P > 0.05$) BASED ON SNK MULTIPLE RANGE TEST. MEANS WITH DIFFERENT LETTER EXPONENTS ARE SIGNIFICANTLY DIFFERENT ($P < 0.05$)

Sites	Current (cm/sec) mean	Temperature (C°) mean	Dissolved O_2 (ppm) mean	pH mean	Total Alkalinity (ppm) mean	Total Hardness ($CaCO_3$ ppm) mean	Chloride (NaCl ppm) mean
1	40.23^{a} (± 8.84)	21.8^{a} (± 1.9)	8.32^{a} (± 0.37)	5.43^{ab} (± 0.41)	5.34^{a} (± 1.60)	4.89^{a} (± 1.28)	12.27^{a} (± 2.76)
2	35.97^{b} (± 8.84)	21.1^{ab} (± 2.2)	8.23^{a} (± 0.35)	5.27^{a} (± 0.42)	5.25^{a} (± 1.89)	5.01^{a} (± 1.59)	11.84^{ab} (± 2.81)
3	45.11^{c} (± 5.49)	20.2^{bc} (± 3.1)	8.73^{b} (± 0.66)	5.61^{c} (± 0.32)	4.32^{b} (± 0.93)	5.88^{b} (± 1.47)	11.38^{b} (± 2.23)
4	47.55^{c} (± 8.53)	20.0^{c} (± 2.1)	8.32^{a} (± 0.29)	5.53^{bc} (± 0.35)	4.37^{b} (± 1.15)	5.16^{ac} (± 1.27)	12.16^{a} (± 2.70)
5	55.17^{d} (± 7.01)	19.9^{c} (± 2.8)	8.44^{a} (± 0.43)	5.48^{bc} (± 0.37)	4.37^{b} (± 1.57	5.37^{c} (± 1.10)	11.33^{b} (± 1.88)

SECTION III

MATERIALS AND METHODS

The five collecting sites on Rocky Creek were sampled monthly from July 1978 to June 1979 for benthic macro-invertebrates with a 15.24 cm X 16.51 cm ponar grab. Four ponar grabs of the substrate were taken at each station during each collection. These four ponar grabs sampled 0.1 m^2 of substrate. The density of benthic macro-invertebrates for each collection date at each site is reported as numbers/m^2 (see Appendix). This was accomplished by multiplying the actual numbers collected by 10.

Qualitative samples were also taken at each site for most of the collection dates. Kick samples using a 1.6 mm mesh minnow seine were taken during most months at all stations except station 4. The water at site 4 was usually too deep to effectively use the seine. Light traps were run monthly at each station from November 1978 to June 1979. Both adult and immature macro-invertebrates were identified to the lowest taxonomic level possible (taxa were usually identified to genus).

As a measure of diversity, the Shannon-Wiener index (H') (Reference 5) was used because it incorporates both species richness and species evenness. This is calculated by:

$$H' = -\Sigma\ p_i \log_2 p_i$$

where p_i is n/N
n_i is the number of individuals of the ith species of the collecting site being considered.
N is the total number of individuals per site.

Evenness (J') is calculated by:

$$J' = H'/\log_2 s$$

where s is the species richness (species number) per site.

Although Wilhm and Dorris (Reference 6), Olive and Dambach (Reference 7), and others have stated that H' is dimensionless and not affected by sample size (N), Sanders (Reference 8), Pielou (Reference 5), Fager (Reference 9), and Simberloff (Reference 10) have shown that this index is sensitive to sample size in many instances. However, no mathematically or conceptually sound alternative has been proposed. The sites in this study were sampled equally. The differences in sample sizes therefore probably reflect true biological differences among the sites (see Table 4). For this reason, no attempt was made to minimize the effect of sample size on the diversity index. Pearson produce-moment correlation coefficients were calculated to determine which of the components of diversity was most important.

Besides using annual and seasonal diversity trends to compare the community structure of the sites, a similarity index between each of the sites was calculated to determine what proportion of the taxa the sites shared. This index (I) was calculated by:

$$I = 2C/A + B$$

where C is the number of taxa found at both sites.
A is the number of taxa found at site A.
B is the number of taxa found at site B.

An analysis of the community trophic structure at each of the sites was also carried out. The functional group method of Merritt and Cummins (Reference 11) was used to assign each taxon of macro-invertebrates to a trophic category. The sites were then compared with respect to the densities of various functional groups.

SECTION IV

RESULTS

1. COMMUNITY COMPOSITION

During the course of this study, 4615 benthic macro-invertebrates representing 65 taxa were collected using the ponar grab sampler (Table 2). Another 20 taxa were collected using qualitative methods (Table 3). Therefore, a total of 85 taxa (mostly genera) was found in Rocky Creek. The Appendix lists the densities of each taxon at each station for each month. In the quantitative samples, aquatic insects made up 89% of the total number and the remainder was made up of crustaceans, mollusks, and oligochaets. Of the insects, the Diptera were the most abundant accounting for 65% of the total invertebrates collected with the Chironomidae comprising from 45 to 75% of the total invertebrate fauna of each site. Other abundant groups include the Oligochaeta (9.4%), Coleoptera (8.9%), Trichoptera (6.9%), Plecoptera (3.6%), Odonata (2.6%), and Ephemeroptera (1.9%). In the light traps, the dominant group was the Trichoptera while in the kick samples it was the Odonata.

Table 2 also shows that only a small number of genera are abundant and common to all sites. As mentioned earlier, the Chironomidae were very abundant at all sites, especially site 3. The other commonly encountered invertebrates were: Hexatoma sp. (Diptera); Stenelmis sp. (Coleoptera); Brachycentrus sp., Micrasema sp., Hydropsyche sp., and Agarodes sp. (Trichoptera); Allocapnia sp. (Plecoptera); Gomphus sp. and Progomphus sp. (Odonata); Hexagenia sp. and Isonychia sp. (Ephemeroptera); and Oligochaeta (Annelida). Most of the uncommon or rare species were usually found at only one or a few sites but occasionally they were found in low numbers at all of the sites.

Differences in the distribution of genera are indicative of differences in habitat. As previously mentioned, the data in Table 1 indicate that there are habitat differences among the sites. However, differences in a fauna that is composed mostly of rare and uncommon genera can lead to incorrect conclusions about habitat differences if care is not taken in the interpretation of data. If a taxon is rare, and is not collected at a site, this might mean that it cannot live there because the habitat is not suitable. It could, however, also mean that the taxon does live there but our sampling methods failed to collect it. For this reason, differences in abundances of the more common taxa should be given more weight when talking about habitat differences among sites. In spite of the numerous rare taxa, an analysis of similarity (Table 4) between sites shows that they were very similar and that they shared from 71 to 86% of their fauna.

TABLE 2. ACTUAL AND RELATIVE ABUNDANCES OF BENTHIC MACRO-INVERTEBRATES COLLECTED AT FIVE SITES IN ROCKY CREEK (QUANTITATIVE SAMPLES ONLY). TOTAL NUMBER OF INVERTEBRATES COLLECTED WAS 4615. TROPHIC RELATIONSHIPS (FUNCTIONAL GROUPS) ARE BASED ON MERRITT AND CUMMINS (REFERENCE 11)

Taxa	Trophic Relationship	Total Numbers	% Composition				
			Site 1	Site 2	Site 3	Site 4	Site 5
ARTHROPODA		4160	89.02	91.61	97.06	88.50	85.22
INSECTA		4103	88.63	89.29	96.76	86.86	84.59
DIPTERA		2997	71.50	63.06	74.69	57.76	60.55
Ceratopogonidae	Predators	272	9.98	4.38	1.07	4.52	10.86
Chironomidae	Collectors/Predators	2496	53.65	50.17	71.63	52.22	45.09
Empididae		2	--	--	--	0.08	0.21
Hemeradromia sp.	Predators/Collectors	2	--	--	--	0.08	0.21
Ephydridae		1	--	--	--	0.08	--
Notiphila sp.	Collectors	1	--	--	--	0.08	--
Tabanidae		30	0.38	0.69	0.61	0.08	2.71
Chrysops sp.	Collectors	28	0.38	0.60	0.61	--	2.71
Tabanus sp.	Predators	2	--	*0.09*	--	*0.08*	--
Tipulidae		191	7.49	7.82	1.38	0.47	1.47
Brachypremna sp.	Shredders	25	1.54	0.60	--	--	0.42
Hexatoma sp.	Predators	138	4.99	6.01	1.23	0.31	0.84
Limnophila sp.	Predators	14	0.58	0.52	--	0.08	0.21
Molophilus sp.	Collectors	1	--	--	--	0.08	--
Tipula sp.	Shredders	13	0.38	0.69	0.15	--	--
Simuliidae		3	--	--	--	0.23	--
Simulium sp.	Filterers	3	--	--	--	0.23	--
Unknown Diptera	Unknown	2	--	--	--	0.08	0.21
COLEOPTERA		411	5.99	9.89	9.66	11.85	5.85
Dytiscidae		10	0.10	0.09	--	0.08	1.46
Agabus sp.	Predators	2	0.10	0.09	--	--	--
Coptotomus sp.	Predators	8	--	--	--	0.08	1.46
Elmidae		394	4.89	9.54	9.66	11.77	3.76
Stenelmis sp.	Scrapers	394	4.89	9.54	9.66	11.77	3.76

TABLE 2. ACTUAL AND RELATIVE ABUNDANCES OF BENTHIC MACRO-INVERTEBRATES COLLECTED AT FIVE SITES IN ROCKY CREEK (QUANTITATIVE SAMPLES ONLY). TOTAL NUMBER OF INVERTEBRATES COLLECTED WAS 4615. TROPHIC RELATIONSHIPS (FUNCTIONAL GROUPS) ARE BASED ON MERRITT AND CUMMINS (REFERENCE 11) (CONTINUED)

Taxa	Trophic Relationship	Total Numbers	% Composition				
			Site 1	Site 2	Site 3	Site 4	Site 5
Gyrinidae		4	--	0.26	--	--	0.21
Dineutes sp.	Predators	1	--	--	--	--	0.21
Gyrinus sp.	Predators	3	--	0.26	--	--	--
Hydrophilidae		2	--	--	--	--	0.42
Helophorus sp.	Shredder	1	--	--	--	--	0.21
Hydrochara sp.	Unknown	1	--	--	--	--	0.21
Ptilodactylidae		1	0.10	--	--	--	--
Anchytarus sp.	Shredders	1	0.10	--	--	--	--
TRICHOPTERA		319	2.02	5.68	8.88	10.61	7.94
Brachycentridae		111	--	--	0.15	6.00	6.89
Brachycentrus sp.	Filterers	72	--	--	0.15	4.13	3.76
Micrasema sp.	Shredders	39	--	--	--	1.87	3.13
Calamoceratidae		14	--	0.17	--	0.94	--
Anisocentropus sp.	Shredders	14	--	0.17	--	0.94	--
Hydropsychidae		86	0.29	0.44	8.12	1.87	0.21
Cheumatopsyche sp.	Filterers	8	--	0.09	0.77	0.16	--
Diplectrona sp.	Filterers	3	--	0.26	--	--	--
Hydropsyche sp.	Filterers	49	0.29	0.09	3.37	1.71	0.21
Macronema sp.	Filterers	25	--	--	3.83	--	--
Potamyia sp.	Filterers	1	--	--	0.15	--	--
Hydrotilidae		2	--	--	--	0.16	--
Hydroptila sp.	Herbivores/Scrapers	2	--	--	--	0.16	--
Leptoceridae		14	--	0.34	--	0.70	0.21
Oecetis sp.	Predators	14	--	0.34	--	0.70	0.21
Molannidae		2	--	--	0.15	--	0.21
Molanna sp.	Scrapers	2	--	--	0.15	--	0.21
Philopotamidae		9	--	--	0.46	0.47	--
Chimarra sp.	Filterer	9	--	--	0.46	0.47	--

TABLE 2. ACTUAL AND RELATIVE ABUNDANCES OF BENTHIC MACRO-INVERTEBRATES COLLECTED AT FIVE SITES IN ROCKY CREEK (QUANTITATIVE SAMPLES ONLY). TOTAL NUMBER OF INVERTEBRATES COLLECTED WAS 4615. TROPHIC RELATIONSHIPS (FUNCTIONAL GROUPS) ARE BASED ON MERRITT AND CUMMINS (REFERENCE 11) (CONTINUED)

Taxa	Trophic Relationship	Total Numbers	% Composition				
			Site 1	Site 2	Site 3	Site 4	Site 5
Phryganeidae		5	0.19	0.26	--	--	--
Banksiola sp.	Shredders	1	--	0.09	--	--	--
Ptilostomis sp.	Shredders	4	0.19	0.17	--	--	--
Polycentropodidae		10	--	0.52	--	0.31	--
Polycentropus sp.	Predators	10	--	0.52	--	0.31	--
Sericostomatidae		66	1.54	3.95	--	0.16	0.42
Agarodes sp.	Shredders	66	1.54	3.95	--	0.16	0.42
PLECOPTERA		164	4.80	7.99	1.23	0.70	0.84
Capniidae		150	4.61	7.47	0.77	0.62	0.42
Allocapnia sp.	Shredders	150	4.61	7.47	0.77	0.62	0.42
Peltoperlidae		1	--	--	--	--	0.21
Peltoperla sp.	Shredders	1	--	--	--	--	0.21
Perlidae		13	0.19	0.52	0.46	0.08	0.21
Perlesta sp.	Predators	13	0.19	0.52	0.46	0.08	0.21
ODONATA		118	0.48	0.69	0.61	5.23	7.10
Coenagrionidae		18	--	0.26	--	0.39	2.09
Enallagma sp.	Predators	18	--	0.26	--	0.39	2.09
Cordulegastridae		1	--	--	--	--	0.21
Cordulegaster sp.	Predators	1	--	--	--	--	0.21
Gomphidae		90	0.48	0.34	0.46	4.37	4.59
Gomphus sp.	Predators	64	0.38	0.34	0.15	3.04	3.34
Progomphus sp.	Predators	26	0.10	--	0.31	1.33	1.25
Libellulidae		1	--	--	--	--	0.21
Pantala sp.	Predators	1	--	--	--	--	0.21
Macromiidae		8	--	0.09	0.15	0.47	--
Macromia sp.	Predators	8	--	0.09	0.15	0.47	--

TABLE 2. ACTUAL AND RELATIVE ABUNDANCES OF BENTHIC MACRO-INVERTEBRATES COLLECTED AT FIVE SITES IN ROCKY CREEK (QUANTITATIVE SAMPLES ONLY). TOTAL NUMBER OF INVERTEBRATES COLLECTED WAS 4615. TROPHIC RELATIONSHIPS (FUNCTIONAL GROUPS) ARE BASED ON MERRITT AND CUMMINS (REFERENCE 11) (CONTINUED)

Taxa	Trophic Relationship	Total Numbers	% Composition				
			Site 1	Site 2	Site 3	Site 4	Site 5
EPHEMEROPTERA		89	3.64	1.89	1.69	0.71	1.89
Baetiscidae		6	--	--	0.77	--	0.21
Baetisca sp.	Collectors	6	--	--	0.77	--	0.21
Ephemerellidae		10	0.19	0.17	0.31	0.31	--
Ephemerella sp.	Collectors	10	0.19	0.17	0.31	0.31	--
Ephemeridae		38	2.88	0.52	--	0.08	0.21
Hexagenia sp.	Collectors	38	2.88	0.52	--	0.08	0.21
Heptageniidae		5	0.19	--	--	--	0.63
Stenonema sp.	Collectors	5	0.19	--	--	--	0.63
Siphlonuridae		28	0.38	1.20	0.61	0.16	0.84
Isonychia sp.	Filterers	28	0.38	1.20	0.61	0.16	0.84
Unknown Ephemeroptera	Unknown	2	--	--	--	0.16	--
LEPIDOPTERA		3	--	0.09	--	--	0.42
Noctuidae		1	--	0.09	--	--	--
Archanara sp.	Shredder	1	--	0.09	--	--	--
Pyralidae		2	--	--	--	--	0.42
Parargyractis sp.	Scrapers	2	--	--	--	--	0.42
MEGALOPTERA		2	0.20	--	--	--	--
Corydalidae		2	0.20	--	--	--	--
Neohermes sp.	Predators	1	0.10	--	--	--	--
Nigronia sp.	Predators	1	0.10	--	--	--	--
HEMIPTERA		1	0.10	--	--	--	--
Veliidae		1	0.10	--	--	--	--
Rhagovelia sp.	Predators	1	0.10	--	--	--	--
CRUSTACEA		57	0.39	2.32	0.30	1.64	0.63
DECAPODA		48	0.29	1.89	0.30	1.40	0.63
Palaemonetes sp.	Filterers	19	--	0.69	0.15	0.78	--
Procambus sp.	Generalists	29	0.29	1.20	0.15	0.62	0.63

TABLE 2. ACTUAL AND RELATIVE ABUNDANCES OF BENTHIC MACRO-INVERTEBRATES COLLECTED AT FIVE SITES IN ROCKY CREEK (QUANTITATIVE SAMPLES ONLY). TOTAL NUMBER OF INVERTEBRATES COLLECTED WAS 4615. TROPHIC RELATIONSHIPS (FUNCTIONAL GROUPS) ARE BASED ON MERRITT AND CUMMINS (REFERENCE 11) (CONCLUDED)

Taxa	Trophic Relationship	Total Numbers	% Composition				
			Site 1	Site 2	Site 3	Site 4	Site 5
ISOPODA		9	0.10	0.43	--	0.24	--
Asellus sp.	Shredders/Scavengers	1	0.10	--	--	--	--
Gammarus sp.	Shredders/Scavengers	6	--	0.43	--	0.08	--
Sphaeroma sp.	Shredders/Scavengers	2	--	--	--	0.16	--
ANNELIDA		433	11.80	8.33	2.30	10.44	13.36
OLIGOCHAETA	Collectors	433	11.80	8.33	2.30	10.44	13.36
MOLLUSCA		21	--	--	0.15	1.01	1.46
PELECYPODA		21	--	--	0.15	1.01	1.46
Pisidium sp.	Filterers	21	--	--	0.15	1.01	1.46
NEMATOMORPHA	Parasites of insects as immatures and do not feed as adults.	1	--	--	0.15	--	--

TABLE 3. MACRO-INVERTEBRATES COLLECTED BY LIGHT TRAP (L) AND KICK SAMPLE (K) METHODS AND NOT COLLECTED IN ANY OF THE QUANTITATIVE (PONAR GRAB) SAMPLES. TROPHIC RELATIONSHIPS (FUNCTIONAL GROUPS) ARE BASED ON MERRITT AND CUMMINS (REFERENCE 11)

Taxa	Trophic Relationship	Site 1	Site 2	Site 3	Site 4	Site 5
TRICHOPTERA						
Baraeidae						
Baraea sp.	Collectors	--	--	L	--	--
Hydroptilidae						
Mayatrichia sp.	Unknown	--	--	--	L	--
Orthotrichia sp.	Herbivores	--	--	L	L	--
Oxyethira sp.	Herbivores	--	--	L	--	--
Lepidostomatidae						
Lepidostoma sp.	Shredders	--	--	--	L	--
Leptoceridae						
Ceraclea sp.	Collectors	L	L	--	--	L
Nectopsyche sp.	Shredders	L	L	L	L	L
Triaenodes sp.	Shredders	--	--	--	--	L
Limnephilidae						
Pyenopsyche sp.	Shredders	L	L	L	L	L
Philopotamidae						
Wormaldia sp.	Collectors	--	--	L	--	--
Phryganeidae						
Agrypnia sp.	Shredders	L	--	--	--	--
Polycentropodidae						
Neureclipses sp.	Filterers	--	--	L	--	--
Nyctiophylas sp.	Predators	--	L	L	L	L
Psychomyiidae						
Lype sp.	Collectors	L	--	L	L	L
PLECOPTERA						
Perlidae						
Acroneuria sp.	Predators	L,K	K	K	K	K
MEGALOPTERA						
Corydalidae						
Corydalus sp.	Predators	K	--	L,K	K	K
Chauliodes sp.	Predators	--	L	--	--	--
HEMIPTERA						
Belostomatidae	Predators	--	K	--	--	--
Corixidae	Predators	K	--	--	--	--
COLEOPTERA						
Dytiscidae						
Rhantus sp.	Predators	K	--	--	--	K

TABLE 4. SIMILARITY INDICES BETWEEN ROCKY CREEK SITES. THE UPPER RIGHT VALUES ARE SIMILARITIES BASED ON BOTH QUANTITATIVE (PONAR GRAB) AND QUALITATIVE (LIGHT TRAP AND KICK SAMPLE) COLLECTIONS. THE LOWER LEFT VALUES ARE SIMILARITIES BASED ON QUANTITATIVE COLLECTIONS ONLY

	Site 1	Site 2	Site 3	Site 4	Site 5
Site 1	--	0.73	0.74	0.75	0.73
Site 2	0.84	--	0.73	0.74	0.71
Site 3	0.86	0.74	--	0.74	0.75
Site 4	0.82	0.83	0.83	--	0.72
Site 5	0.75	0.71	0.73	0.64	--

2. COMMUNITY DIVERSITY

The sites and their annual values of s, H', J', and N are given in Table 5. Values of H' and J' are given in two forms, one with the Chironomidae included and the other with the Chironomidae excluded. This was done because the Chironomidae was such a dominant group at all sites that its inclusion almost always made for a very uneven distribution of abundance among the taxa, thus lowering the diversity measure. This lowered diversity might obscure the fact that many different taxa do occur at a site and might lead to erroneous conclusions about the water quality of Rocky Creek. The patterns of both the annual and seasonal diversity measures were similar with and without Chironomidae with only the magnitude of H' and J' values being different.

Site 5 had the highest diversity, while site 3 had the lowest. All of the other sites had intermediate diversities. When only the quantitative samples are considered, site 4 had the highest number of species while site 1 had the lowest. When all samples are considered, the number of species at all sites is about equal. Site 5 had the highest evenness and site 3 the lowest. However, when Chironomidae are excluded, the evenness at site 5 is quite high indicating that the invertebrates other than Chironomidae are fairly evenly distributed in abundance. These results suggest that even though both richness and evenness contribute to the diversity measure, evenness is more important in determining H'. The correlation coefficients calculated between H' and J', s, and N support this idea. Both s and J' were significantly correlated with H' ($r_{H',s} = 0.68$, $P < 0.05$; $r_{H',J'} = 0.98$, $P < 0.001$) but J' had a much higher correlation suggesting that evenness was most important in determining diversity. There was no significant correlation between H' and N ($r = 0.13$, $P > 0.05$) indicating that sample size did not effect diversity in this study.

Seasonal patterns of taxonomic diversity at each of the sites are given in Table 7. When considering only the quantitative samples, all of the sites have the highest number of species in June or July after which the richness declines and then begins to increase again from January to March. When all samples are considered, most sites have the highest richness from March to June indicating that many insects are emerging at this time (although they are no longer in the substrate as immatures, they are around the area as adults). The greater the difference between the quantitative and total richness, the greater the probability that an emergence period has occurred at that time.

Seasonal patterns of taxonomic evenness at each of the sites are given in Table 8. The highest evenness was in October for site 1, in November for sites 2, 3, and 4, and in September for site 5. These times of peak evenness correspond with times of lowest larval chironomid densities at the sites (see Appendix). Light trap records show that these are also times of maximum chironomid emergence at the sites.

Some of these seasonal changes are due to fluctuations in larval chironomid numbers while others are due to changes in stream conditions and to the life cycles (emergence, drift, etc.) of the taxa.

TABLE 5. ROCKY CREEK COLLECTION SITES AND THEIR ANNUAL VALUES OF TAXONOMIC RICHNESS (s), DIVERSITY (H'), EVENNESS (J') AND SAMPLE SIZE (N) BASED ON QUANTITATIVE (PONAR GRAB) SAMPLES. NUMBERS IN PARENTHESES ARE VALUES WITHOUT CHIRONOMIDAE FOR H' AND J' AND ARE RICHNESS VALUES THAT INCLUDE LIGHT TRAP AND KICK SAMPLE COLLECTIONS FOR s

Site	s	H'	J'	N
1	27 (52)	2.495 (3.233)	0.525 (0.688)	1041
2	35 (53)	2.794 (3.601)	0.545 (0.708)	1163
3	28 (50)	1.836 (3.438)	0.382 (0.723)	651
4	39 (52)	2.733 (3.630)	0.517 (0.692)	1282
5	35 (53)	3.063 (3.770	0.597 (0.741)	478

TABLE 6. SEASONAL PATTERNS OF INVERTEBRATE TAXONOMIC DIVERSITY AT THE ROCKY CREEK COLLECTION SITES BASED ON QUANTITATIVE (PONAR GRAB) SAMPLES. NUMBERS IN PARENTHESES ARE DIVERSITY VALUES WITH CHIRONOMIDAE EXCLUDED

Sites	July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June	mean H' / mo.
1	2.651 (3.270)	2.252 (2.041)	2.347 (2.854)	3.172 (3.007)	1.645 (1.521)	2.069 (2.313)	1.385 (2.152)	nc	1.991 (2.156)	1.655 (2.158)	2.130 (2.400)
2	3.041 (3.218)	2.173 (2.391)	1.507 (2.613)	2.126 (1.852)	3.112 (2.975)	2.029 (3.070)	2.591 (2.831)	1.852 (2.628)	1.942 (2.316)	2.460 (2.629)	2.283 (2.652)
3	1.538 (2.257)	2.295 (2.524)	1.053 (0.818)	1.416 (2.419)	2.182 (1.896)	0.955 (1.357)	1.386 (1.922)	0.642 (2.040)	1.874 (2.541)	1.098 (2.522)	1.444 (2.030)
4	2.277 (2.603)	1.105 (1.761)	2.347 (2.860)	1.379 (2.684)	1.982 (1.681)	2.051 (3.114)	2.587 (3.198)	1.854 (1.888)	2.496 (2.345)	2.974 (3.026)	2.105 (2.516)
5	2.534 (3.358)	2.071 (2.059)	2.670 (2.505)	1.857 (1.611)	2.292* (2.292)	1.624 (2.118)	2.546 (2.406)	1.959 (2.178)	2.098 (2.280)	2.853 (2.675)	2.024 (2.348)

nc no collection

* no Chironomidae collected

TABLE 7. SEASONAL PATTERNS OF INVERTEBRATE TAXONOMIC RICHNESS AT THE ROCKY CREEK COLLECTION SITES BASED ON QUANTITATIVE (PONAR GRAB) SAMPLES. NUMBERS IN PARENTHESES ARE RICHNESS VALUES THAT INCLUDE LIGHT TRAP AND KICK SAMPLE COLLECTIONS

Sites	July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June	mean S / mo.
1	17	9	12	11	8	10	10	nc	8	7	10.2
	(26)	(12)	(17)	(17)	(20)	(18)	(18)		(24)	(21)	(19.2)
2	19	16	12	11	12	12	12	11	7	9	12.1
	(26)	(19)	(18)	(17)	(23)	(19)	(21)	(22)	(19)	(18)	(20.2)
3	11	12	5	6	6	5	5	6	9	8	7.4
	(15)	(19)	(11)	(12)	(19)	(16)	(21)	(17)	(10)	(27)	(17.8)
4	13	5	12	9	6	13	15	10	10	21	11.4
	(13)	(5)	(12)	(9)	(8)	(13)	(15)	(23)	(20)	(26)	(14.4)
5	18	7	8	5	8	6	9	8	9	10	8.8
	(22)	(12)	(11)	(11)	(18)	(13)	(17)	(19)	(22)	(27)	(17.2)

nc no collection

TABLE 8. SEASONAL PATTERNS OF INVERTEBRATE TAXONOMIC EVENNESS AT THE ROCKY CREEK COLLECTION SITES BASED ON QUANTITATIVE (PONAR GRAB) SAMPLES. NUMBERS IN PARENTHESES ARE EVENNESS VALUES WITH CHIRONOMIDAE EXCLUDED

Sites	July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June	mean J' / mo.
1	0.649 (0.818)	0.710 (0.680)	0.655 (0.825)	0.917 (0.905)	0.548 (0.542)	0.623 (0.703)	0.417 (0.679)	nc	0.637 (0.768)	0.590 (0.835)	0.638 (0.751)
2	0.716 (0.772)	0.543 (0.612)	0.420 (0.625)	0.615 (0.558)	0.868 (0.860)	0.566 (0.887)	0.723 (0.818)	0.535 (0.791)	0.692 (0.896)	0.776 (0.876)	0.645 (0.770)
3	0.445 (0.679)	0.640 (0.730)	0.454 (0.409)	0.504 (0.936)	0.844 (0.817)	0.411 (0.679)	0.597 (0.961)	0.248 (0.879)	0.591 (0.847)	9.366 (0.898)	0.510 (0.784)
4	0.615 (0.726)	0.476 (0.881)	0.655 (0.827)	0.435 (0.895)	0.767 (0.724)	0.554 (0.869)	0.662 (0.840)	0.558 (0.596)	0.751 (0.740)	0.677 (0.700)	0.615 (0.780)
5	0.608 (0.822)	0.738 (0.797)	0.890 (0.892)	0.800 (0.806)	0.764* (0.764)	0.628 (0.912)	0.803 (0.802)	0.653 (0.776)	0.662 (0.760)	0.859 (0.844)	0.741 (0.818)

nc no collection

* no Chironomidae collected

3. COMMUNITY TROPHIC STRUCTURE

Tables 2 and 3 give the trophic category or functional groups of each of the taxa. These trophic relationships are classified primarily according to feeding mechanism rather than food eaten. Their use in this report has been slightly modified from that of Merritt and Cummins (Reference 11). They are defined as follows:

Shredders	-	Feed on decomposing vascular plant tissues--coarse particulate organic matter (CPOM). Primarily chewers and wood borers (detritivores).
Collectors	-	Feed on decomposing animal and plant fine particulate organic matter (FPOM). Mostly gatherers or deposit (sediment) feeders (detritivores).
Filterers	-	Feed on decomposing animal and/or plant FPOM. Filter or suspension feeders (detritivores).
Scrapers	-	Feed by scraping attached periphyton from mineral and organic surfaces.
Predators	-	Feed on living animal tissue. Either eat animals whole or pierce tissues and cells and suck fluids.
Herbivores	-	Feed on living hydrophyte plant tissue. Either chew on plant or pierce tissues and cells and suck fluids.
Generalists	-	Feed on a variety of living and non-living plant and animal foods.
Scavengers	-	Feed on dead plant and animal tissues of various sizes.

The relative abundances of the major functional groups found at each of sites in Rocky Creek are given in Table 9. These data show that collectors and predators were the dominant groups and had fairly constant abundances at all sites. The number of shredders decreased with increasing stream order while the filterers and scrapers increased. These results conform, very generally, to the River Continuum Model (Reference 12) which predicts this shift in functional group abundances as the size (order) of the stream increases. Station 5, however, does not conform completely to the predicted pattern since the number of scrapers decreases.

TABLE 9. RELATIVE ABUNDANCES OF MAJOR FUNCTIONAL GROUPS COLLECTED AT FIVE SITES IN ROCKY CREEK BASED ON QUANTITATIVE (PONAR GRAB) COLLECTIONS ONLY

Functional Group	% Composition				
	Site 1	Site 2	Site 3	Site 4	Site 5
Shredders	8.46	13.66	0.92	3.98	4.81
Collectors (Gatherers)	51.39	43.23	51.98	45.98	47.33
Filterers	0.67	2.33	9.64	8.65	6.27
Scrapers	4.89	9.54	9.81	11.77	3.97
Predators	34.49	29.61	27.37	29.23	36.32

SECTION V

DISCUSSION

Although similarity indices (Table 4) between sites indicated that most of the fauna at each of the sites was similar, Table 2 showed that the abundances of the various taxa were not always similar. Physico-chemical factors (Table 1), and diversity values (Table 5) showed that the sites were different in their habitat and community structure. Seasonal changes in community composition were due primarily to drift and life histories of the taxa. Much of the difference in both annual and seasonal diversity was due to changes in the larval densities of Chironomidae at each site. The most important factor affecting diversity was the evenness component, with low evenness resulting from high chironomid densities. The number of taxa did not vary much from site to site.

Correlations of various physico-chemical parameters from Table 1 with annual diversity, richness, and evenness produced no significant relationships, possibly because of the small number of degrees of freedom in the analysis. However, the correlation between H' and the variance of temperature at each of the sites were significant ($r = 0.90$, $P < 0.05$). This suggests that those stations with high variability in temperature over a year's time will have a lower diversity than those with less variation. This is probably because the highly variable sites form a less stable habitat resulting in fewer organisms being able to live there. The more tolerant organisms such as Chironomidae would occur in higher densities in these areas. Site 3 had the largest temperature variance, the highest chironomid density, and the lowest diversity. Other factors such as hardness (Table 1) may also play a role in determining the composition and diversity of communities at the sites.

As stated earlier, the results of the trophic analysis of the communities were as predicted by the River Continuum Model. The smaller (in area) portions of the stream (sites 1 and 2) were shallow and had much canopy cover resulting in large amounts of Course Particulate Organic Matter (CPOM) entering the stream. The amount of CPOM compared to the stream area is larger in smaller streams than in larger (higher order) streams. Therefore the number of shredders per unit area of small streams are higher than in larger streams. The collectors and predators should remain constant because their food source remains constant. In larger streams the canopy is more open allowing more sunlight to reach the water with a resultant increase in periphyton growth. Thus the numbers of scrapers increase. Filterers become more abundant in larger streams because the faster current allows them to filter the Fine Particulate Organic Matter (FPOM) produced by the action of shredders upstream. The drop in the number of scrapers at sight 5 is due no doubt to a drop in the periphyton abundance at that site. The reasons for this are not known at present.

The presence of Chironomidae has often been associated with poor water quality. This is true if Chironomidae are the only organisms found. When Chironomidae are found in association with a wide range of other organisms, as was the case in the present study, a different interpretation must be made. The sandy substrate limits the kinds of organisms that can live in the stream and is most favorable for Diptera, especially Chironomidae. Considering the physico-chemical parameter values, the number and kinds of organisms found, and their diversity and trophic structure, it must be concluded that the water

quality of Rocky Creek is very high. The presence of numerous genera of Trichoptera and the abundance of the Plecoptera Allocapnia and Acroneuria reinforces this conclusion. The high numbers of Chironomidae and the low abundance of numerous other macro-invertebrates are primarily a function of the sandy substrate and not of water quality.

REFERENCES

1. Young, A. L., C. E. Talken, and W. E. Ward. Studies on the Ecological Impact of Repetitive Aerial Applications of Herbicides on the Ecosystem of Test Area C-52A, Eglin AFB, Florida, AFATL-TR-75-142, Eglin AFB, Florida, October 1975.

2. Crews, R. C., Aquatic Baseline Survey of Selected Test Areas on Eglin Air Force Base Reservation, Florida, AFATL-TR-76-4, Eglin AFB, Florida, January 1975.

3. Crews, R. C., Species Diversity Indices of the Fish Populations of Streams Draining Selected Test Areas on Eglin Air Force Base Reservation, Florida, AFATL-TR-76-145, Eglin AFB, Florida, December 1976.

4. Crews, R. C., S. M. Lefstad, G. G. Wyman, and C. I. Miller. Water Quality: Streams and Ponds on Selected Test Areas on Eglin Air Force Base, Florida, AFATL-TR-77-72, Eglin AFB, Florida, May 1977.

5. Pielou, E. C. An Introduction to Mathematical Ecology, Wiley-Interscience, N.Y., 1969.

6. Wilhm, J. L., and T. C. Dorris. Biological Parameters for Water Quality Criteria, Bioscience 18:447-81, 1968.

7. Olive, J. H., and C. A. Dambach. Benthic Macro-invertebrates as Indexes of Water Quality in Whetstone Creek, Morrow County, Ohio (Scioto River Basin), Ohio Journal of Science 13:129-49, 1973.

8. Sanders, H. L. Marine Benthic Diversity: A Comparative Study, American Naturalist 102:243-82.

9. Fager, E. W. Diversity: A Sampling Study, American Naturalist 106:293-310, 1972.

10. Simberloff, D. Properties of the Rarefaction Diversity Measurement, American Naturalist 106:353-7, 1972.

11. Merritt, R. W. and K. W. Cummins. An Introduction to the Aquatic Insects of North America. Kendall/Hunt, Dubuque, Iowa, 1978.

12. Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. The River Continuum Concept, Canadian Journal of Fisheries and Aquatic Sciences 37:130-37, 1980.

(The reverse of this page is blank)

APPENDIX

Density (no./m^2) of benthic macro-invertebrates in Rocky Creek at each site for each monthly collection. Entries of L (light trap) of K (kick sample) indicate that the taxon was collected at that time and place by qualitative sampling methods.

SITE #1

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
DIPTERA										
Ceratopogonidae	210		220		80	230	300			
Chironomidae	1040	350	680	30	10	960	1710 (L)	650 (L)	420 (L)	390 (L)
Tabanidae										
Chrysops sp.	20				10	10				
Tipulidae										
Brachypremna sp.	50	40	20	10	20	20				
Hexatoma sp.	100	120	30	50 (K)	10	30 (K)	80		60	40
Limnophila sp.	20					20	20			
Tipula sp.	10									30
COLEOPTERA										
Dytiscidae										
Agabus sp.			10							
Coptotomus sp.					K					
Rhantus sp.				K						
Elmidae										
Stenelmis sp.	130	90	80	80	20	10	20	L	60 (L)	20
Ptilodactylidae										
Anchytarsus sp.									10	
TRICHOPTERA										
Brachycentridae										
Brachycentrus sp.					L					
Micrasema sp.										L
Hydropsychidae										
Cheumatopsyche sp.									L	L
Hydropsyche sp.	10 (K)	20			L	K	L	L	L	L

SITE #1 (continued)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
Macronema sp.								L	L	
Potamyia sp.									L	
Hydroptilidae										
Hydroptila sp.					L		L	L	L	L
Leptoceridae										
Ceraclea sp.										L
Nectopsyche sp.					L				L	L
Oecetis sp.					L				L	L
Triaenodes sp.									L	L
Limnephilidae										
Pycnopsyche sp.					L					
Molannidae										
Molanna sp.							L		L	
Philopotamidae										
Chimarra sp.	K						L		L	L
Phryganeidae										
Agrypnia sp.									L	
Ptilostomis sp.				20						
Polycentropodidae										
Nyctiophylax sp.									L	
Psychomyiidae										
Lype sp.									L	
Sericostomatidae										
Agarodes sp.	60		60	30 (K)		10		L	L	L
PLECOPTERA										
Capniidae										
Allocapnia sp.	50	330	70	20			10			
Perlidae										
Acroneuria sp.	K					K				
Perlesta sp.	20	10								

SITE #1 (continued

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
ODONATA										
Coenagrionidae										
Enallagma sp.							K			
Gomphidae										
Gomphus sp.	K		K	K	K	K	K		40	K
Progomphus sp.	K	K	K	10 (K)	K	K				K
Macromiidae										
Macromia sp.	K	K	K	K						
EPHEMEROPTERA										
Ephemerellidae										
Ephemerella sp.	10						10			
Ephemeridae										
Hexagenia sp.	80		10	40 (K)	10 (K)	130 (K)	20 (K)			10 (K)
Heptageniidae										
Stenonema sp.	K		20			K				
Siphlonuridae										
Isonychia sp.	10	10	20							
MEGALOPTERA										
Corydalidae										
Chauliodes sp.								L	L	
Corydalus sp.	K			K						
Neohermes sp.										10
Nigronia sp.									10	
HEMIPTERA										
Corixidae					K					
Veliidae										
Rhagovelia sp.				10 (K)			K			

SITE #1 (continued)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
CRUSTACEA										
Decapoda										
Palaemonetes sp.	K		K	K	K	K	K			
Procambarus sp.	20 (K)	K	K	K	K	K		20	10	K
Isopoda										
Asellus sp.							10			
ANNELIDA										
Oligochaeta	260	10	70	40 (K)	280 (K)	180	130	180	170	90 (K)

SITE # 2

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
DIPTERA										
Ceratopogonidae	150		110		180	50				20
Chironomidae	630	1110	1080	250	40 (L)	890	260 (L)	800	520	260
Tabanidae										
Chrysops sp.	10	10	20	10		10	10			
Tabanus sp.								10		
Tipulidae										
Brachypremna sp.	10	10	10	10	80	10		10		10
Hexatoma sp.	140	40		30	70	110	60	100	100	50
Limnophila sp.	40		10	10						
COLEOPTERA										
Dytiscidae										
Agabus sp.								10		
Coptotomus sp.	K									
Elmidae										
Stenelmis sp.	390		30	10	60	80	80	160	110 (L)	130
Gyrinidae										
Dineutes sp.							K			
Gyrinus sp.									30	
TRICHOPTERA										
Brachycentridae										
Brachycentrus sp.							L	L		
Micrasema sp.									L	
Calamoceratidae										
Anisocentropus sp.		20				K		L	L	
Hydropsychidae										
Cheumatopsyche sp.		10						L	L	

SITE #2 (continued)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
Diplectrona sp.		30						L	L	
Hydropsyche sp.					10			L	L	
Potamyia sp.										L
Hydroptilidae										
Hydroptila sp.		10						L	L	
Leptoceridae										
Ceraclea sp.								L	L	
Nectopsyche sp.					L			L	L	L
Oecetis sp.	30				L		10	L	L	
Limnephilidae										
Pycnopsyche sp.					L					
Molannidae										
Molanna sp.							L	L		
Philopotamidae										
Chimarra sp.							L		L	L
Phryganeidae										
Banksiola sp.							10			
Ptilostomis sp.						20				
Polycentropodidae										
Nyctiophylax sp.								L	L	
Polycentropus sp.	60									
Sericostomatidae										
Agarodes sp.	140	20		10	120		20	50 (L)	60 (L)	40
PLECOPTERA										
Capniidae										
Allocapnia sp.	90	600	20		120					40
Peltoperlidae										
Peltoperla sp.		60								
Perlidae										
Acroneuria sp.			K	K		K	K			
Perlesta sp.				K		K				

SITE #2 (continued)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
ODONATA										
Coenagrionidae										
Enallagma sp.	20 (K)					10				
Gomphidae										
Gomphus sp.	K	K	K	K	K		10 (K)	20		10 (K)
Progomphus sp.	K	10 (K)	K	10 (K)	10 (K)	K	K			K
Macromiidae										
Macromia sp.	K	K	K	K	10 (K)	K	K			K
EPHEMEROPTERA										
Baetiscidae										
Baetisca sp.					K	K				
Ephemerellidae										
Ephemerella sp.	20									
Ephemeridae										
Hexagenia sp.	K	K	10	20	K		10 (K)			20 (K)
Heptageniidae										
Stenonema sp.					K					
Siphlonuridae										
Isonychia sp.	40	30	10		10	30	20			
LEPIDOPTERA										
Noctuidae										
Archanara sp.			10							
MEGALOPTERA										
Corydalidae										
Chauliodes sp.									L	
HEMIPTERA										
Belostomatidae			K							
Veliidae										
Rhagovelia sp.					K	K				

SITE #2 (Concluded)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
CRUSTACEA										
Decapoda										
Palaemonetes sp.	10 (K)		10 (K)	K	K	60 (K)	K			K
Procambarus sp.	30 (K)	10 (K)	K	30 (K)	K	30 (K)	10 (K)	30		K
Isopoda										
Gammarus sp.		30						10	10	
ANNELIDA										
Oligochaeta	10	150	140	300 (K)	100	80	100	30	60	K

SITE #3

Taxa	Collection Dates (1979-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
DIPTERA										
Ceratopogonidae	40				30					
Chironomidae	720	540	580	270	60 (L)	430	130	1060 (L)	40	480
Tabanidae										
Chrysops sp.			10	30		K				
Tipulidae										
Hexatoma sp.				10	60 (L)	10				
Tipula sp.								10		
COLEOPTERA										
Dytiscidae										
Coptotomus sp.					K					
Elmidae										
Stenelmis sp.	18	60	180	20	10	70	10	20	40	40
Gyrinidae										
Dineutes sp.		K	K		K	K	K			
TRICHOPTERA										
Baraeidae										
Baraea sp.							L			
Brachycentridae										
Brachycentrus sp.		10			L			L	L	
Micrasema sp.									L	L
Hydropsychidae										
Cheumatopsyche sp.	10	40						L	L	L
Hydropsyche sp.		120			L	10 (K)	K,L	L	80 (L)	10 (L)
Macronema sp.		250			L			L	L	L
Potamyia sp.		10								

SITE #3 (continued)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
Hydroptilidae										
Hydroptila sp.									L	L
Orthatrichia sp.										L
Oxyethira sp.									L	
Leptoceridae										
Ceraclea sp.								L	L	L
Nectopsyche sp.					L			L	L	L
Oecetis sp.							L	L	L	L
Triaenodes sp.										L
Limnephilidae										
Pycropsyche sp.					L					
Molannidae										
Molanna sp.										10 (L)
Philopotamidae										
Chimarra sp.	10	20					L	L	L	L
Wormaldia sp.										L
Polycentropodidae										
Neureclipses sp.					L					
Nyctiophylax sp.							L	L		L
Polycentropus sp.							L	L		
Psychomyiidae										
Lype sp.							L			
Sericostomatidae										
Agarodes sp.							L	L	L	L
PLECOPTERA										
Capniidae										
Allocapnia sp.	10						L	20	20	
Perlidae										
Acroneuria sp.						K				
Perlesta sp.	10 (K)	10					K		10	

SITE #3 (continued)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
ODONATA										
Coenagrionidae										
Enallagama sp.			K				K			
Gomphidae										
Gomphus sp.	K	K	10 (K)	K	K	K				K
Progomphus sp.	K	K	10 (K)	K	10 (K)	K	K			K
Macromiidae										
Macromia sp.	10 (K)	K	K	K	K	K	K			
EPHEMEROPTERA										
Baetiscidae										
Baetisca sp.	10	20		10	K		10			
Ephemerellidae										
Ephemerella sp.						10	10			
Ephemeridae										
Hexagenia sp.						K				
Siphlonuridae										
Isonychia sp.		20		10 (K)						
MEGALOPTERA										
Corydalidae										
Corydalus sp.		K	K	K		K				
HEMIPTERA										
Veliidae										
Rhagovelia sp.					10					
CRUSTACEA										
Decapoda										
Palaemonetes sp.		K	K	K	K	K	K		10	K
Procambarus sp.	K	K	K	K	K	K	K		10	K
ANNELIDA										
Oligochaeta	20 (K)	10		10		K	20 (K)	50	50	10

SITE #3 (Concluded)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
MOLLUSCA										
Pelecypoda									10	10
Psidium sp.										10

SITE #4

Taxa	Collection Dates (1978-79) July	Aug	Sept	Ovt	Nov	Jan	Mar	April	May	June
DIPTERA										
Ceratopogonidae	140		70		170		190			10
Chironomidae	1080	380	660	1230	40	1190	680	550 (L)	200	690
Empididae										
Hemerodromia sp.							10			
Ephydridae										
Notiphila sp.										10
Tabanidae										
Tabanus sp.							10			
Tipulidae										
Hexatoma sp.	10		10				10			10
Limnophila sp.								10		
Molophilus sp.								10		
Simuliidae										
Simulium sp.	30									
Unknown Diptera									10	
COLEOPTERA										
Dytiscidae										
Coptotomus sp.					10					L
Elmidae										
Stenelmis sp.	370	20	80	20	130	90	80	120 (L)	30	
TRICHOPTERA										
Brachycentridae										
Brachycentrus sp.	140		130	30	10	140	20 (L)		20	40
Micrasema sp.			80					L	30	130
Calamoceratidae										
Anisocentropus sp.								L		120

SITE #4 (continued)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
Hydropsychidae								L		
Cheumatopsyche sp.								L	L	20 (L)
Hydropsyche sp.			150			60	10	L	L	L
Macronema sp.								L	L	
Potamyia sp.									L	
Hydroptilidae										
Hydroptila sp.								10 (L)	L	10
Mayatrichia sp.									L	
Orthotrichia sp.								L		
Lepidostomitidae										
Lepidostoma sp.									L	
Leptoceridae										
Nectopsyche sp.					L			L	L	
Oecetis sp.		20	20			20		10 (L)	10	
Limnephilidae										
Pycnopsyche sp.					L					
Molannidae										
Molanna sp.								L		L
Philopotamidae										
Chimarra sp.							60 (L)	L	L	L
Phryganeidae										
Ptilostomis sp.						10				
Polycentropodidae										
Nyctiophylax sp.								L		
Polycentropus sp.							40			
Psychomyiidae										
Lype sp.								L		
Sericostomatidae										
Agarodes sp.	10							10 (L)	L	
PLECOPTERA										
Capniidae										
Allocapnia sp.							30			50

SITE #4 (continued)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
Perlidae										
Acroneuria sp.										L
Perlesta sp.						10				
ODONATA										
Coenagrionidae										
Enallagma sp.				20			10			20
Gomphidae										
Gomphus sp.						140	80	20	50	100
Progomphus sp.	40		10	80	40					
Macromiidae										
Macromia sp.	10			40						100
EPHEMEROPTERA										
Ephemerellidae										
Ephemerella sp.						30				10
Ephemeridae										
Hexagenia sp.	10									
Siphlonuridae										
Isonychia sp.			20							
Unknown Ephemeroptera						20				
MEGALOPTERA										
Corydalidae										
Chauliodes sp.								L		
Corydalus sp.										L
CURSTACEA										
Decapoda										
Palaemonetes sp.				60		40				
Procambarus sp.			10	10					20	40
Isopoda										
Gammarus sp.		10								
Sphaeroma sp.	20									

SITE #4 (Concluded)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
ANNELIDA										
Oligochaeta	240	50		100		80	100	260	220	290
MOLLUSCA										
Pelecypoda										
Pisidium sp.	20		10			20	10	10	30	30

SITE #5

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
DIPTERA										
Ceratopogonidae	210		50		90		110			60
Chironomidae	910	230	10	10		220	120 (L)	300	290 (L)	70
Empididae										
Hemerodromia sp.							10			
Tabanidae										
Chrysops sp.	120									
Tipulidae										
Brachypremna sp.					10	10				
Hexatoma sp.	20						20			
Limnophila sp.					10					
COLEOPTERA										
Dytiscidae										
Coptotomus sp.			10		10 (K)			10	20	20
Rhantus sp.			K			K				
Elmidae										
Stenelmis sp.	50	40		10		30		40 (L)	10	L
Gyrinidae										
Dineutes sp.						K			10	K
Hydrophilidae										
Helophorus sp.							10			
Hydrochara sp.										10
TRICHOPTERA										
Brachycentridae										
Brachycentrus sp.	20			80		20	L			60
Micrasema sp.	110					40		L	L	
Hydropsychidae										
Cheumatopsyche sp.								L	L	L

SITE #5 (continued)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
Hydropsyche sp.								L	L	L
Macronema sp.									L	L
Potamyia sp.								L		
Hydroptilidae										
Hydroptila sp.								L	L	L
Leptoceridae										
Ceraclea sp.								L	L	
Nectopsyche sp.					L				L	
Oecetis sp.								10 (L)		L
Triaenodes sp.								L		
Limnephilidae										
Pycnopsyche sp.					L		K			
Molannidae										
Molanna sp.	10				L		L			
Philopotamidae										
Chimarra sp.							L	L	L	L
Polycentropodidae										
Nyctiophylax sp.								L	L	
Polycentropus sp.									L	
Psychomyiidae										
Lype sp.									L	
Sericostomatidae										
Agarodes sp.		20						L	L	L
PLECOPTERA										
Capniidae										
Allocapnia sp.									20	
Peltoperiidae										
Peltoperia sp.										10
Perlidae										
Acroneuria sp.	K									
Perlesta sp.	10									L

SITE #5 (continued)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
ODONATA										
Coenagrionidae										
Enallagma sp.	10		30	30	10 (K)		K	20		
Cordulegastridae										
Cordulegaster sp.	10									
Gomphidae										
Gomphus sp.	K	50 (K)	20 (K)	K	20 (K)	K	40 (K)	30	10	10 (K)
Progomphus sp.	40 (K)	K	K	K	K	K	K			
Libellulidae										
Pantala sp.	10									K
Macromiidae										
Macromia sp.	K	K		K	K	K	10 (K)			K
EPHEMEROPTERA										
Baetiscidae										
Baetisca sp.								10		
Ephemeridae										
Hexagenia sp.				K	10 (K)					
Heptageniidae										
Stenonema sp.					K				30	
Siphlonuridae										
Isonychia sp.	20	10	10							
LEPIDOPTERA										
Pyralidae										
Parargyractis sp.		10			10					
MEGALOPTERA										
Corydalidae										
Chauliodes sp.								L	L	
Corydalus sp.										L
HEMIPTERA										
Gerridae										
Gerris sp.										K

SITE #5 (Concluded)

Taxa	Collection Dates (1978-79) July	Aug	Sept	Oct	Nov	Jan	Mar	April	May	June
CRUSTACEA										
Decapoda										
Palaemonetes sp.		K		K	K	K	K			K
Procambarus sp.	K	K	K	K	K	K	K		30	
ANNELIDA										
Oligochaeta	60	120 (K)	50	20		10 (K)	50 (K)	120	140	70 (K)
MOLLUSCA										
Pelecypoda										
Pisidium sp.	70						10			